AD-A036 363 BATTELLE COLUMBUS LABS OHIO F/G 1/2
STUDY OF THE EFFECTS OF INCREASED COSTS ON CORPORATE AND BUSINE--ETC(U)
AUG 75 R F PORTER, M A DUFFY, R W COTE DOT-FA74WA-3485

UNCLASSIFIED FAA-AVP-75-13-VOL-1 NL

1 OF 1
AD-A
036 363

END
DATE
FILMED
4-4-77
NTIS

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

AD-A036 363

STUDY OF THE EFFECTS OF INCREASED COSTS ON CORPORATE AND BUSINESS FLYING

VOLUME I. EXECUTIVE SUMMARY

BATTELLE COLUMBUS LABORATORIES, OHIO

12 AUGUST 1975

REPORT NO. FAA-AVP-75-13 DOT-FA 74WA-3485

STUDY OF THE EFFECTS OF INCREASED COSTS ON CORPORATE AND BUSINESS FLYING

VOLUME I. EXECUTIVE SUMMARY

Battelle-Columbus

NOVEMBER 1975

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Office of Aviation Policy
Aviation Forecast Branch
Washington, D.C. 20591

The contents of this report reflect the views of Battelle's Columbus Laboratories, which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policy of the Department of Transportation. This report does not constitute a standard, specification, or regulation.

Technical Report Documentation Page

1. Report No. FAA-AVP-75-13	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle STUDY OF THE EFFECTS OF INCREASED COSTS ON CORPORATE AND BUSINESS FLYING VOLUME I: EXECUTIVE SUMMARY		5. Report Date August 12, 1975
		6. Performing Organization Code
7. Author(s) R. F. Porter, M. A. Duffy, and R. W. Cote		8. Performing Organization Report No.
9. Performing Organization Name and Address BATTELLE Columbus Laboratories 505 King Avenue Columbus, Ohio 43201		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DOT-FA74WA-3485
12. Sponsoring Agency Name and Address Department of Transportation Federal Aviation Administration Office of Aviation Policy Washington, D.C. 20591		13. Type of Report and Period Covered Final Report, June 12, 1974 - August 12, 1975
		14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This report, in four volumes, presents the results of research intended to enhance the utility of the original General Aviation Cost Impact Study (DOT-FA74WA-3118) by (1) identifying subcategories of business/corporate operators with varying effective after-tax sensitivities, (2) redefining the empirical cost impact relationships for business/corporate flying by using an expanded data base, and (3) providing information to permit greater insight into the nature of the business fleet by examining the financial characteristics of corporate owners.

The volumes included in this report are:

Volume I - Executive Summary
Volume II - Research Methodology
Volume III - Planning Guide
Volume IV - Data Base

17. Key Words General Aviation Cost Impact Cost Sensitivity	18. Distribution Statement DISTRIBUTION STATEMENT A Approved for public release; Distribution Unlimited

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 39	22. Price

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

	Page
BACKGROUND	1
Outline of Previous Cost Impact Study Methodology	2
Cost Sensitivity Evaluation	2
Cost Impact Evaluation	3
Purpose of Present Study	3
Objectives	4
Summary of Technical Approach	5
Definition of Aircraft Types	6
DISCUSSION OF RESULTS	6
Cost Sensitivity Analysis	7
Data Base	7
Subcategories of Business/Corporate Aviation	7
Calculation of Annualized Investment Cost Center	11
Structure of the Annualized Cost Center	11
Equivalent Annual Cash Flow	12
Influence Coefficients	13
Cost Sensitivity Models	17
Variable Cost Sensitivity	18
Fixed Cost Sensitivity	18
Composite Business/Corporate Cost Sensitivity Coefficients	18
Sample Calculation	18
Cost Impact Analysis	23
Pooled Regression Equations	24
Individual Time-Series Equations	25
Pooled Turbine-Aircraft Model	27
Comments on Regression Analysis	30

TABLE OF CONTENTS (Continued)

	Page
Business Aircraft Owner Characteristics	30
CONCLUDING REMARKS	31
Cost Sensitivity	31
Cost Impact	35

LIST OF TABLES

Table 1.	Cost Centers	2
Table 2.	Definition of Aircraft Types	6
Table 3.	1972 Business/Corporate Activity and Price Data	8
Table 4.	Average Costs, 1972 (Before Tax)	9
Table 5.	Definition of User Subcategories	10
Table 6.	Estimated Proportion of Aircraft Type in Each User Subcategory	11
Table 7.	Net Annualized Investment Cost Center Based on Discounted Cash Flow Analysis	14
Table 8.	Comparison of Annualized Investment Cost Centers ($/Year - 1972 Data)	15
Table 9.	Influence Coefficients on the Annual Cost of Ownership	16
Table 10.	Cost Sensitivity Relationships - After Tax - 1972 Data	19
Table 11.	1972 Estimates from Pooled Regression Model	26
Table 12.	Coefficients of Time-Series Regression Equations	28
Table 13.	1972 Estimates from Individual Time-Series Models	29
Table 14.	1972 Estimates for Pooled Turbine-Aircraft Model	30

LIST OF FIGURES

		Page
Figure 1.	Percentage of Fortune 1000 Companies Which Operate Business Aircraft	32
Figure 2.	Distribution by Aircraft Type	33
Figure 3.	Distribution of Aircraft - Agriculture Industry	34

FINAL REPORT

on

STUDY OF THE EFFECTS OF INCREASED COSTS ON CORPORATE AND BUSINESS FLYING

VOLUME I: EXECUTIVE SUMMARY

to

FEDERAL AVIATION ADMINISTRATION
OFFICE OF AVIATION POLICY

from

BATTELLE
Columbus Laboratories

by

R. F. Porter, M. A. Duffy, and R. W. Cote

August 12, 1975

BACKGROUND

Projections of general aviation activity are currently made annually in the FAA "Aviation Forecasts" publication series which cover a 10-year period. An increasingly important, but difficult, facet of such projections is the assessment of the effects of potential cost increases associated with possible Federal regulatory actions. In response to this challenge, the FAA, in 1972, sponsored a research program (Contract No. DOT-FA72WA-3118) with Battelle-Columbus* to develop the methodology, back-up data, and results needed to aid FAA planners in the quantitative assessment of the cost impact of proposed regulatory changes.

The current study is an extension of the earlier work, specialized to one particular user category within general aviation, and has been structured to conform as nearly as possible to the definitions, research methodology, and procedures developed for the original study. For this reason, the original cost impact study methodology is reviewed here.

---

* "General Aviation Cost Impact Study" (in four volumes), prepared by Battelle-Columbus for the Office of Aviation Economics, Federal Aviation Administration, June 1973.

Outline of Previous Cost Impact Study Methodology

In brief, the Cost Impact Study provided a procedure for predicting two indicators of general aviation activity: hours flown per year, and number of aircraft in the fleet. Specifically, predictions could be made for six user categories within general aviation. These user categories were:

- Business and Executive* Transportation
- Personal Flying
- Aerial Application
- Instructional Flying
- Air Taxi
- Industrial and Special Flying.

Cost Sensitivity Evaluation

The procedure was divided into two major steps. First, the sensitivity of overall costs of ownership to changes in specific cost centers was established. The overall cost of ownership was segregated into variable costs, which are incurred on an hourly basis; and fixed costs, which are essentially independent of the number of hours flown. The cost centers within each are given in Table 1.

TABLE 1. COST CENTERS

Variable Costs

- Fuel and Oil
- Airframe and Avionics Maintenance
- Engine Maintenance

Fixed Costs

- Annualized Investment
- Hull Insurance
- Medical and Liability Insurance
- Storage and Tie Down
- Federal User Charges
- Miscellaneous Fixed Costs

* In the previous study, "executive" flying denoted the use of a professional crew. In this report, "corporate" flying has that meaning.

Since the absolute and relative values for the cost centers depend upon the type of aircraft, the entire general aviation fleet was considered to be composed of ten standard aircraft types and each was analyzed separately.

The product of the cost sensitivity portion of the analysis was the percentage change in variable, fixed, and total costs which were caused by percentage changes in one or more of the specific cost centers.

Cost Impact Evaluation

Using the results of the cost sensitivity analysis, the two indicators of activity. yearly hours flown, and number of aircraft, could be predicted for each user category and each standard aircraft type. The prediction was based upon a regression analysis of historical response behavior for the years 1965 through 1971. The regression equations which were developed for each user category contain several general economic indicators in addition to the fixed and variable cost effects. In the usual case, if only the effects of changes in the specific cost centers are to be evaluated, without regard to more general indicators of the overall economy, a graphical technique could be employed to obtain the cost impact estimates.

Purpose of Present Study

Because of the limitations of the depth of the previous study, it was not possible to treat several factors which are, intuitively, very relevant to the actual and perceived costs of aircraft ownership and operation. In particular, no accounting was made of crew costs, where professional flight crews were involved, nor were tax effects included in the calculation of costs.

Both of these factors are especially significant to the business/corporate user category which, in terms of hours flown, is the most active category in general aviation. In calendar year 1971, the business/corporate aircraft fleet totaled 35,951 aircraft (primary use) out of a total fleet of 147,621*. Utilization totaled 8.1 million hours out of the general aviation total of 28.6 million hours.

* "General Aviation Cost Impact Study, Volume IV, Data Base", June 1973. It should be noted that these data are somewhat at variance with published FAA statistics. The reasons for discrepancies between published FAA statistics and activity data from Aviation Data Service, Inc., are discussed in Volume IV of this report.

The bulk of the business fleet is made up of single-engine piston and light twin-engine piston aircraft; but in its annual analysis of the "Fortune 1000" large industrial companies in 1973, Aviation Data Service showed that 427 of the nation's largest companies operate 1,341 aircraft, with a relatively large proportion being high-performance, sophisticated aircraft.

The business/corporate fleet covers a wide range of business activity and operational situations. There is also a wide variety of methods used for financing aircraft acquisition and accounting for the costs associated with aircraft ownership and operation. These include the effects of interest rates, financing and leasing plans, depreciation schedules, allocation of pilots' salaries, and accounting methods which can result in differential impacts caused by cost changes. The complexity of this problem could not be adequately treated within the time and funds available in the original study. The research program reported herein was intended to provide a more comprehensive analysis of the business/corporate user category.

Objectives

The objective of this research program was to enhance the usefulness of the original General Aviation Cost Impact Study for the business/corporate category by:

(1) Segregating the description and analysis of the business/corporate user category into several subcategories which more accurately reflect the broad range of business-related aviation activity.

(2) Improving the cost-sensitivity relationships by expanding the concept of the "Annualized Investment" cost center to include the effects of several generic types of financing and accounting methods and to evaluate effective after-tax operating costs.

(3) Expanding the historical data base and redefining the empirical cost impact relationships.

(4) Developing greater insight into the nature of the business fleet by identifying correlations between company characteristics and the aircraft they operate.

Summary of Technical Approach

Ideally, for the most complete integration with the original cost impact study, the approach would have been to define logical subcategories within the major business/corporate classification, and then to develop separate cost sensitivity and cost impact expressions for each subcategory.

Early in the study it became apparent that such an approach, patterned exactly after the first Cost Impact Study, would not be possible; the fundamental impediment being the fact that the historical data base for the impact analysis is segregated only by aircraft type within the business/corporate user category, and by no other descriptors. Thus, for example, the empirical response behavior of a corporation operated, leased aircraft with professional crews could not be isolated from that of the businessman/pilot flying a term-financed aircraft of the same type.

In view of this fact, the primary effort was devoted to the development of expanded and improved cost sensitivity models for logically defined subcategories of business/corporate aviation. With regard to cost impact, the effort was, necessarily, constrained to a reevaluation of the relationships developed during the first cost impact study for business/corporate flying using an expanded data base.

In an additional part of this program, not related directly to the earlier Cost Impact Study, the business characteristics of the operators of approximately 3,350 corporate-owned aircraft were examined and correlations were established between aircraft ownership and the various financial descriptors of the companies.

Definition of Aircraft Types

For brevity, the aircraft types under consideration are referred to by a numerical designation throughout this report. The definition of aircraft types is given in Table 2.

TABLE 2. DEFINITION OF AIRCRAFT TYPES

Type No.	Definition
1	Single-engine piston, 1 to 3 place
2	Single-engine piston, 4 place and over
3	Twin-engine piston, under 12,500 lb TOGW
4	Twin-engine piston, over 12,500 lb TOGW
5	Multi-engine piston, over 12,500 lb TOGW
6	Twin-engine turboprop, under 20,000 lb TOGW
7	Twin-engine turboprop, over 20,000 lb TOGW
8	Twin-engine turbojet/fan, under 20,000 lb TOGW
9	Twin-engine turbojet/fan, over 20,000 lb TOGW
10	Multi-engine turbojet/fan, under 20,000 lb TOGW
11	Multi-engine turbojet/fan, over 20,000 lb TOGW
12	Rotary-wing, piston engine
13	Rotary-wing, turbine engine
14	Other

DISCUSSION OF RESULTS

This section is a summary of the more complete discussions contained in Volume II, "Research Methodology".

Cost Sensitivity Analysis

Data Base

For data consistency, Calendar Year 1972 was selected as the base year. As in the previous cost impact study, Aviation Data Service, Inc. of Wichita, Kansas, was engaged by Battelle-Columbus to provide support in establishing the necessary data base. For the cost sensitivity analysis, these consisted of the following items:

(1) The number of aircraft in the business/corporate category
(2) The annual hours flown
(3) The average initial purchase price, including avionics
(4) Average costs of ownership and operation.

Items (1) and (2) were available for all aircraft types (see Table 2) except Type 10. Aircraft price and cost data were available for only the ten most important aircraft types. For this reason, no cost sensitivity analysis was performed for aircraft Types 4, 5, 10, or 14.

The basic data are tabulated in Tables 3 and 4. The Annualized Investment Cost Center of Table 4 was computed by ADS as the aircraft purchase price plus sales tax multiplied by the annual percent depreciation; the same gross definition used in the previous Cost Impact Study.

Subcategories of Business/Corporate Aviation

A necessary step in expanding the concept of the Annualized Investment cost center was the identification of logical subcategories of the total business/corporate users.

Initially, 24 possible subcategories were identified through segregation based upon the nature of the operator (incorporated or unincorporated); the type of flight crew (professional or nonprofessional); and the means of acquisition (lease, finance, or outright purchase). Two types of leases were

TABLE 3. 1972 BUSINESS/CORPORATE ACTIVITY AND PRICE DATA

Aircraft Type*	Number of Aircraft	Annual Hours Flown	Average Initial Purchase Price (1972 Dollars)
1	3,151	340,528	19,980
2	22,942	4,045,822	28,506
3	11,640	3,363,960	117,596
6	1,002	525,048	514,350
7	213	159,963	1,500,000
8	538	305,046	939,250
9	405	254,745	2,187,500
11	220	135,740	2,250,000
12	336	87,696	50,750
13	236	86,848	118,750

* See Table 2 for Type Definitions.

SOURCE: Aviation Data Service, Inc.

originally considered. In the "wet" lease arrangement, the lessor provides the aircraft, maintenance, insurance, and often the flight crews. The "dry" lease provides for a specified monthly lease payment for the aircraft alone. For both the finance and outright purchase options, two methods of accounting for depreciation were considered; a straight-line depreciation to some residual value over the depreciation life of the aircraft and an accelerated "double declining to straight-line" method.

The combination of 24 possible subcategories of users for each of the ten aircraft types under consideration yields 240 possible subsegments of the business/corporate fleet. Fortunately, several of the possible user subcategories and subcategory/aircraft-type combinations could be eliminated. For example, the wet lease option was judged to be too similar to a rental operation and not properly a part of the business/corporate user category. Furthermore, early calculations indicated a clear tax advantage to the accelerated depreciation schedule; consequently, the straight-line depreciation

TABLE 4. AVERAGE COSTS, 1972

(Before Tax)

Cost Center	Aircraft Type* 1	2	3	6	7	[illegible]	9	11	12	13
Variable Costs ($/Hr)										
Fuel & Oil	4.95	7.37	18.20	34.70	111.90	141.13	184.31	292.88	6.75	12.43
A/F & Av Main	1.82	3.00	9.50	20.93	91.50	51.05	120.29	121.71	10.49	15.89
Eng Main	1.36	2.11	9.29	21.59	16.25	42.30	64.29	93.05	3.67	17.46
Fixed Costs ($/Yr)										
A.I.**	2,997	4,276	17,639	70,215	180,000	95,797	218,750	225,000	7,612	16,625
Hull Insurance	899	1,140	2,470	9,362	22,500	12,454	24,063	22,500	6,090	11,875
Med & Lia Ins	175	306	360	1,500	3,600	1,380	1,500	3,940	350	680
Storage & Tie Down	554	638	1,391	2,833	12,325	9,107	10,060	11,836	625	827
Fed User Charges	25	76	148	407	1,416	613	1,331	1,513	29	137
Misc Fixed Costs	93	125	208	2,368	6,400	4,373	9,182	9,280	122	204

SOURCE: Aviation Data Service, Inc.

* For definition of aircraft type, see Table 2.

** ADS computation, prior to refinement of this program.

schedule option was eliminated. A further reduction in the number of subcategories was effected by assuming that the number of unincorporated users employing professional flight crews is insignificant.

The final selection of user subcategories reduced to nine in number. Throughout the remainder of this report, they are referred to by Roman numerals as defined in Table 5.

TABLE 5. DEFINITION OF USER SUBCATEGORIES

Subcategory	Operator	Crew	Acquisition Method
I	Unincorporated	Nonprofessional	Lease
II	Unincorporated	Nonprofessional	Finance
III	Unincorporated	Nonprofessional	Own
IV	Incorporated	Nonprofessional	Lease
V	Incorporated	Nonprofessional	Finance
VI	Incorporated	Nonprofessional	Own
VII	Incorporated	Professional	Lease
VIII	Incorporated	Professional	Finance
IX	Incorporated	Professional	Own

Following the delineation of viable subcategories, it was necessary to establish an estimate of the relative number of aircraft, of each type, operated by each user subcategory. These estimates were based upon data from "Census of U.S. Civil Aircraft--Calendar Year 1972", published by the Office of Management Systems, FAA, combined with intuitive judgment. The results of the estimating procedure are given in Table 6.

TABLE 6. ESTIMATED PROPORTION OF AIRCRAFT TYPE IN EACH USER SUBCATEGORY

	Aircraft Type									
Subcategory	1	2	3	6	7	8	9	11	12	13
I	.020	.010	.005	--	--	--	--	--	--	--
II	.060	.030	.015	--	--	--	--	--	--	--
III	.020	.010	.005	--	--	--	--	---	--	--
IV	.170	.180	.121	.024	--	.008	--	---	.134	.080
V	.510	.540	.363	.036	--	.012	--	---	.402	.120
VI	.170	.180	.121	--	--	--	--	---	.134	--
VII	.010	.010	.074	.376	.400	.392	.400	.400	.066	.320
VIII	.030	.030	.222	.564	.600	.588	.600	.600	.198	.480
IX	.010	.010	.074	--	--	--	--	--	.066	--

Calculation of Annualized Investment Cost Center

A major reason for undertaking this research program was the necessity to obtain a more realistic estimate of the Annualized Investment cost center. As mentioned previously, the method of calculation used in the previous study, and used by ADS in the data given in Table 4, was a simple averaging of the initial price plus sales tax over a fixed time period.

In the current program, the Annualized Investment Cost Center is evaluated as the true after-tax yearly cost of acquisition, based upon a discounted cash-flow analysis.

Structure of the Annualized Cost Center. The parameters included in the computation of the Annualized Investment for each user subcategory/aircraft type combination are:

- Aircraft purchase price
- Downpayment percentage
- Financing term
- Interest rate
- Lease rate
- Lease term
- Lease prepayment
- Lease disposal price
- Crew salaries
- IRS depreciation life
- Service life
- Residual value after depreciation
- Sales tax rate
- Personal income tax rate (unincorporated owners)
- Corporate income tax rate
- Investment tax credit
- Business return on investment (ROI)

A discussion of the baseline values of these parameters, and the basis for these values, is given in Volume II, "Research Methodology".

Equivalent Annual Cash Flow. Since each of the 51 practical subsegments (combinations of user subcategory and aircraft type) can be expected to generate different (and irregular) negative cash flows over the aircraft service life, it is necessary to convert the unequal multiyear flow of costs to an equivalent single annual figure for each subsegment. This was done by determining the present value of the total annual cost for each year, using an appropriate discount rate, the discount rate being the company's internal rate of return on investment (ROI). Dividing the total present value of annual costs by the sum of the discount factors, for each year, yields the equivalent annual cost. This approach yields a valid, convenient, and simple comparison between alternatives, especially when they differ in original cost and expected service life.

The equivalent annual cost obtained from the discounted cash-flow analysis for each of the subsegments is presented in Table 7, along with the weighted average for each aircraft type based upon the distribution of Table 6. It is interesting to note that the lease option results in the lowest annual cost, followed by the finance option then the outright purchase option. These comparisons are, however, somewhat sensitive to the values of the parameters chosen for the baseline case. In particular, the finance option is better than the outright purchase, here, because an internal rate of return on investment of 12 percent was assumed, whereas the effective interest rate on aircraft loans in 1972 was substantially less than 12 percent.

Table 8 is a comparison of the Annualized Investment values of the present study with those prepared by Aviation Data Service, Inc., for the year 1972, by the method used in the previous Cost Impact Study. It appears that, in general, the effect of the addition of crew costs in this analysis tends to offset the tax benefits except for turbine-powered, fixed-wing aircraft. For rotary wing aircraft, the simple ADS calculation greatly under-estimates the annualized investment, primarily because of crew cost effects.

Influence Coefficients

Several important parameters, required as input data for the Annualized Investment calculations, are subject to change or conjecture. Therefore, in a departure from the methodology of the previous study, the concept of "influence coefficients" is introduced to permit modification to the baseline values of the Annualized Investment cost center.

Influence coefficients were developed to indicate the dependence of annual ownership costs on the values of sales tax, investment tax credit, mortgage interest rate, salaries, and aircraft purchase price. Influence coefficients were developed for each subcategory/aircraft-type combination to describe the percentage change in Annualized Investment to unit changes in each of the aforementioned parameters. This effort is summarized in Table 9 which lists the influence coefficients for the composite business/corporate user category. These values were obtained by weighting the individual subcategory values, for each aircraft type, according to the distribution of Table 6.

TABLE 7. NET ANNUALIZED INVESTMENT COST CENTER BASED ON DISCOUNTED CASH FLOW ANALYSIS

Dollars/Year, After Taxes

User Subcategory	Aircraft Type 1	2	3	6	7	8	9	11	12	13
I	2,461	3,511	14,248							
II	2,917	4,162	17,038							
III	3,126	4,460	18,398							
IV	1,606	2,292	9,269	30,321		55,369			5,023	9,360
V	2,168	3,093	12,660	35,967		65,678			5,506	12,784
VI	2,472	3,527	14,549						6,279	
VII	21,306	21,992	29,669	55,071	115,576	82,219	158,404	168,939	30,930	36,210
VIII	21,868	22,793	33,060	60,717	132,039	92,528	182,414	193,634	32,356	39,634
IX	22,172	23,227	34,949						33,129	
Weighted Average*	3,176	4,058	20,017	56,974	125,454	87,867	172,810	183,756	14,362	32,894

* Based upon distribution of Table 6.

TABLE 8. COMPARISON OF ANNUALIZED INVESTMENT COST CENTERS ($/Yr - 1972 Data)

Aircraft Type	ADS Method	Current Analysis	Percentage Change from ADS
1. Single-Engine Piston, 1-3 Seat	2,997	3,176	+ 6.0
2. Single-Engine Piston, 4 Place & Over	4,276	4,058	- 5.1
3. Twin-Piston, Under 12,500 lb TOGW	17,639	20,017	+13.5
6. Twin Turboprop, Under 20,000 lb TOGW	70,215	56,974	-18.9
7. Twin Turboprop, Over 20,000 lb TOGW	180,000	125,454	-30.3
3. Twin-Turbojet/Fan, Under 20,000 lb TOGW	95,797	87,867	- 8.3
9. Twin Turbojet/Fan, Over 20,000 lb TOGW	218,750	172,810	-21.0
11. Multi-Turbojet/Fan, Over 20,000 lb TOGW	225,000	183,756	-18.3
12. Rotary Wing, Piston	7,612	14,362	+88.7
13. Rotary Wing, Turbine	16,625	32,894	+97.9

TABLE 9. INFLUENCE COEFFICIENTS ON THE ANNUAL COST OF OWNERSHIP

Composite Business/Corporate User Category

	Aircraft Type									
	1	2	3	6	7	8	9	11	12	13
$\frac{\Delta A.I.}{\Delta \text{ Sales Tax}}$, %/Pt.	0.45	0.48	0.40	0.24	0.32	0.28	0.34	0.33	0.28	0.17
$\frac{\Delta A.I.}{\Delta \text{ Inv. Tax Crdt.}}$, %/Pt.	-1.14	-1.36	-1.14	-1.44	-1.90	-1.70	-2.00	-1.96	-0.60	-0.70
$\frac{\Delta A.I.}{\Delta \text{ Int. Rate}}$, %/Pt.	0.68	0.76	0.62	1.24	1.68	1.50	1.78	1.72	0.38	0.38
$\frac{\Delta A.I.}{\Delta \text{ Salary}}$, %/%	0.31	0.24	0.38	0.41	0.22	0.30	0.17	0.20	0.62	0.65
$\frac{\Delta A.I.}{\Delta \text{ A/C Price}}$, %/%	0.70	0.75	0.62	0.59	0.78	0.70	0.83	0.80	0.38	0.35

The application of the influence coefficients will be illustrated in a later section of this report.

Cost Sensitivity Models

Cost sensitivity is defined as the change in variable costs, fixed costs, or total costs resulting from a given change in a specific cost center. For each aircraft type-user subcategory combination, the cost sensitivity is determined by substituting appropriate values into the general cost sensitivity model.

$$\text{\% Change in Sum of Cost Centers} = \text{\% Change in Cost Center} \times \left(\frac{\text{Cost Center}}{\text{Sum of Cost Centers}} \right)$$

The ratio of (Cost Center/Sum of Cost Centers) is the cost sensitivity coefficient. Since these coefficients clearly depend upon the distribution of the costs relative to the total, they vary with time. The rise in fuel costs relative to other cost centers during 1974 illustrates the time-varying nature of the cost sensitivity coefficients. Nevertheless, the need for consistency demands that the cost structure be based upon the latest year's available data--in this case, 1972.

In applying the cost sensitivity models, it is implicitly assumed that other cost centers are held constant. Therefore, the relationships are linear and it is not necessary to construct curves of the cost sensitivity relationships; instead, only the cost sensitivity coefficient is needed, regardless of the size of the increment.

In computing the cost sensitivity coefficients, it is necessary to convert the before-tax costs of Table 4 to after-tax values, to be consistent with the newly developed Annualized Investment cost centers of Table 7. The user subcategory determined whether the corporate or noncorporate tax rate was used; the assumed tax rates being 50 percent and 36 percent, respectively.

Variable Cost Sensitivity. Using data from Tables 3 and 4, the variable costs in dollars per hour were converted to dollars per year, based upon the average utilization rate for each aircraft type. Because of the lack of data it was necessary to assume that the utilization rate, for a given aircraft type, is independent of the user subcategory. Consequently, the variable cost structure is dependent only upon aircraft type.

Fixed Cost Sensitivity. The fixed cost structure is dependent upon the user subcategory because of the variation of the Annualized Investment values.

Composite Business/Corporate Cost Sensitivity Coefficients. Coefficients for each user subcategory and aircraft type combination can be found in Volume II, "Research Methodology". Using the distribution among user subcategories given in Table 6, the cost sensitivity coefficients were also computed for the total business/corporate fleet. These values are given in Table 10.

Sample Calculation

The use of the Annualized Investment Influence Coefficients together with the Cost-Sensitivity Coefficients is explained in detail in Volume III, "Planning Guide". Their use is illustrated here for a hypothetical increase in the investment tax credit.

It is hypothesized that the investment tax credit is to be increased from 7 to 12 percent. We will establish the resulting changes in fixed and total costs for the composite business/corporate fleet for aircraft type 9, the twin-engine turbojet/fan, over 20,000 lb TOGW.

The total investment tax credit change is five points, and the appropriate Annualized Investment Influence Coefficient is found in Table 9.

$$\frac{\Delta \text{ A.I.}}{\Delta \text{ Investment Tax Credit}} = -2.0\%/\text{Pt.}$$

TABLE 10. COST SENSITIVITY RELATIONSHIPS - AFTER TAX - 1972 DATA

CASE: COMPOSITE BUS/CORP

AIRCRAFT TYPE

	1			2			3		
Variable Cost	$/Yr	% VC	% TC	$/Yr	% VC	% TC	$/Yr	% VC	% TC
Fuel & Oil	272	60.96	6.14	666	59.04	10.50	2,704	49.21	9.72
A/F & AV	102	22.37	2.25	271	24.02	4.27	1,411	25.68	5.07
Eng	76	16.67	1.68	191	16.93	3.01	1,380	25.11	4.96
Total	456		10.07	1,128		17.78	5,495		19.75
Fixed Costs	$/Yr	% FC	% TC	$/Yr	% FC	% TC	$/Yr	% FC	% TC
A.I.	3,176	77.96	70.11	405.8	77.80	63.96	20,016	89.67	71.96
Hull Ins	462	11.34	10.20	578	11.08	9.11	1,244	5.57	4.47
Med & Liab Ins	90	2.21	1.99	155	2.97	2.44	181	0.81	0.65
Hangar, Etc.	285	7.00	6.30	323	6.19	5.09	700	3.14	2.52
Fed Fee	13	0.32	0.29	39	0.75	0.61	75	0.34	0.27
Misc	48	1.17	1.06	63	1.21	0.99	105	0.47	0.38
Total	4,074		89.93	5,216		82.22	22,321		80.25
Grand Total	4,530			6,344			27,816		

TABLE 10. (Continued)

CASE: COMPOSITE

	AIRCRAFT TYPE 6			7			8		
Variable Cost	$/Yr	% VC	% TC	$/Yr	% VC	% TC	$/Yr	% VC	% TC
Fuel & Oil	9,092	44.94	10.64	42,018	50.94	18.18	40,010	60.19	23.77
A/F & AV	5,483	27.10	6.42	34,358	41.66	14.87	14,473	21.77	8.60
Eng	5,656	27.96	6.62	6,102	7.40	2.64	11,992	18.04	7.13
Total	20,231		23.68	82.478		35.69	66,475		39.50
Fixed Costs	$/Yr	% FC	% TC	$/Yr	% FC	% TC	$/Yr	% FC	% TC
A.I.	56,972	87.37	66.68	125,454	84.44	54.30	87,868	86.29	52.21
Hull Ins	4,681	7.18	5.48	11,250	7.57	4.87	6,227	6.12	3.70
Med & Liab Ins	750	1.15	0.88	1,800	1.21	0.78	690	0.68	0.41
Hangar, Etc.	1,416	2.17	1.66	6,162	4.15	2.67	4,553	4.47	2.71
Fed Fee	204	0.31	0.24	708	0.48	0.31	307	0.30	0.18
Misc	1,184	1.82	1.39	3,200	2.15	1.38	2,186	2.15	1.30
Total	65,207		76.32	148,574		64.31	101,831		60.50
Grand Total	85.438			231,052			168,306		

TABLE 10. (Continued)

CASE: COMPOSITE

AIRCRAFT TYPE

	9			11			12		
Variable Cost	$/Yr	% VC	% TC	$/Yr	% VC	% TC	$/Yr	% VC	% TC
Fuel & Oil	57,965	49.96	18.58	90,354	57.69	24.76	879	32.25	4.25
A/F & AV	37,831	32.61	12.13	37,547	23.98	10.29	1,369	50.19	6.61
Eng	20,219	17.43	6.48	28.706	18.33	7.87	479	17.56	2.31
Total	116,015		37.19	156,607		42.92	2,727		13.17
Fixed Costs	$/Yr	% FC	% TC	$/Yr	% FC	% TC	$/Yr	% FC	% TC
A.I.	172,810	88.22	55.41	183,756	88.24	50.36	14,364	79.92	69.39
Hull Ins	12,032	6.14	3.86	11,250	5.40	3.08	3,045	16.94	14.71
Med & Liab Ins	750	0.38	0.24	1,970	0.95	0.54	175	0.97	0.84
Hangar, Etc.	5,030	2.57	1.61	5,918	2.84	1.62	312	1.74	1.51
Fed Fee	665	0.34	0.21	706	0.34	0.19	15	0.08	0.07
Misc	4,591	2.34	1.47	4,640	2.23	1.27	61	0.34	0.2
Total	195,878		62.81	208,240		57.08	17,972		86.8
Grand Total	311,893			364,847			20,699		

TABLE 10. (Continued)

CASE: COMPOSITE

AIRCRAFT TYPE

	13								
Variable Cost	$/Yr	% VC	% TC	$/Yr	% VC	% TC	$/Yr	% VC	% TC
Fuel & Oil	2,287	27.15	4.74						
A/F & AV	2,924	34.71	6.06						
Eng	3,212	38.14	6.66						
Total	8,423		17.47						
Fixed Costs	$/Yr	% FC	% TC	$/Yr	% FC	% TC	$/Yr	% FC	% TC
A.I.	32,896	82.66	68.22						
Hull Ins	5,987	15.04	12.42						
Med & Liab Ins	330	9.83	0.68						
Hangar, Etc.	413	1.04	0.86						
Fed Fee	69	0.17	0.14						
Misc	102	0.26	0.21						
Total	39,797		82.53						
Grand Total	48,220								

So, ΔA.I. = 5(-2.0) = -10.0%.

In other words, the 5 point change in investment tax credit causes a reduction in the annualized investment of 10 percent. This is then translated into a fixed cost increment by substituting the appropriate cost-sensitivity coefficient from Table 10 into Equation (2).

$$\% \Delta FC = \% \Delta A.I. \times \frac{A.I.}{FC} \quad . \qquad (2)$$

From Table 10, the annualized investment is seen to constitute 88.22 percent of the fixed costs for Aircraft Type 9. Converting to a decimal fraction, and using Equation (2),

$$\% \Delta FC - (-10.0)\ (.8822) = -8.82.$$

Similarly, with regard to total costs,

$$\% \Delta TC = (-10.0)\ (.5541) = -5.54.$$

Accordingly, for this particular aircraft type, and considering the business/corporate fleet as a whole, a 5 point increase in the investment tax credit could be expected to reduce the total after-tax costs of ownership and operation by 5.54 percent.

Cost Impact Analysis

The purpose of the cost impact analysis was to develop a set of mathematical relationships which reflect the behavioral response of business/corporate operators (and potential operators) to those factors affecting the cost of aircraft ownership and operation.

As in the previous Cost Impact Study, regression analysis was used to obtain expressions for

(1) The number of aircraft in operation (fleet size), and

(2) The number of hours flown (fleet utilization).

Unlike the cost sensitivity analysis, the cost impact portion treats the business/corporate user category as a whole, and does not attempt to predict the behavior of the individual user subcategories identified in Table 5. As mentioned previously, this limitation exists because the historical data base for the impact analysis is segregated only by aircraft type within the business/corporate category.

The data base for the cost impact analysis consisted of the activity data for the years 1965 through 1971 (see Volume IV of the previous Cost Impact Study), augmented by the newly acquired data for 1972.

Pooled Regression Equations

The set of independent variables considered in this analysis was consistent with the variables identified for the business/executive user category during the previous Cost Impact Study.

The cornerstone of the rationale is the assumption that fixed cost is the primary cost factor influencing the fleet size, whereas variable cost is the primary determinant for fleet utilization. This assumption is the basis for constructing pooled regression relationships across different aircraft types. The assumption was tested during this study and appears valid for turbine powered aircraft, but less applicable to piston-powered airplanes.

In the previous Cost Impact Study, the decision was made to combine both time series and cross-section samples to estimate the parameters in a single equation. Here, cross-section data refers to observations at an instant of time on different aircraft types. In a cross-section sample, corporate profits, consumer income, and other variables are held constant. Thus, in principle, if a single independent variable can be identified which explains the difference in activity levels between aircraft types, it is possible to pool the cross-section data with the time-series data. As in the previous study, fixed and variable costs were assumed to play the role in the two regression equations for activity levels.

The two equations for the entire business/corporate category are:

Number of Aircraft

$$
\begin{aligned}
\ln N = \underset{(-2.82)}{-4.244} &+ \underset{(10.27)}{0.599} \ln H + \underset{(9.75)}{1.228} \ln (PRD/FC) \\
&+ \underset{(1.06)}{0.363} \ln PRF + \underset{(5.27)}{0.233} \ln (N-1)
\end{aligned}
$$

$$\bar{R}^2 = 0.98$$

Number of Hours

$$\ln H = 1.608 + 1.819 \ln ECH - 0.567 \ln VC$$
$$\quad (0.57) \quad (2.36) \qquad\qquad (-5.88)$$
$$\bar{R}^2 = 0.43.$$

Both equations are based on 56 observations. The variables are defined as follows, and the basic data are given in Table 24 of Volume II.

N = the number of aircraft of the types considered

H = the number of hours flown, in thousands

PRD = the productivity of the aircraft by type, expressed in terms of seat miles per hour

FC = annual fixed cost, expressed in 1000's of 1970 dollars

PRF = corporate profits (before tax) and inventory valuation adjustment, expressed in billions of 1970 dollars

N-1 = the number of aircraft in the previous year

ECH = the average compensation per hour for managers, officials, professional, and technical employees, expressed in 1970 dollars

VC = the variable cost per hour expressed in 1970 dollars

$\bar{R}^2$ = a statistical parameter reflecting the extent with which the variation of the dependent variable is explained by the variations in the independent variables. For further discussion see Volume II.

The numbers in parentheses below each coefficient are the t-statistic values used to evaluate the statistical significance of each coefficient. In this analysis, values of the t-statistic greater than about 2.0 can be considered significant.

As a crude test of the ability of the pooled regression equations to estimate the activity of specific aircraft types, the equations were applied for the year 1972 and compared to the observed data. The results are given in Table 11, and indicate that the pooled regression model provides a better fit for fleet size than for fleet utilization. This observation is consistent with the $\bar{R}^2$ values. In particular, the derived utilization for 1972 is quite different from the actual values for aircraft types 1, 2, and 3.

TABLE 11. 1972 ESTIMATES FROM POOLED REGRESSION MODEL

Aircraft Type	Fleet Size		Utilization	
	Actual	Estimated	Actual	Estimated
Composite	40,111	42,583	9,130,852	5,178,993
1	3,151	1,971	340,528	1,726,250
2	22,942	24,479	4,045,822	1,353,428
3	11,640	13,328	3,363,960	730,988
6	1,002	994	525,048	481,577
7	213	200	159,963	266,228
8	538	730	305,046	256,542
9	405	581	254,745	198,418
11	220	300	135,740	165,562

Individual Time-Series Equations

Prompted by the recognized deficiencies of the pooled regression equations, an attempt was made to treat each aircraft type independently, even though the seven data points in a time series is less than normally desired.

The form of the equations is identical to that previously shown:

Number of Aircraft

$$\ln N = a_o + a_1 \ln H + a_2 \ln (PRD/FC) + a_3 \ln PRF + a_4 \ln (N-1)$$

Number of Hours

$$\ln H = b_o + b_1 \ln ECH + b_2 \ln VC$$

In each case (each aircraft type) a t- statistic test was employed to estimate the statistical significance of each of the coefficients of the independent variables.

Table 12 gives the coefficients of the time-series equations. The numbers in parentheses below each coefficient are the associated t-statistic values. Where the analysis indicated no statistical significance whatever, the coefficient values are omitted.

Several serious deficiencies of the time-series model can be inferred from Table 12:

(1) There are no readily discernable patterns relating the significant variables in the equations for different aircraft types. That is, variables that appear significant for some types are not significant for others.

(2) The algebraic signs of the coefficients are not always consistent between aircraft types.

(3) Fixed costs are not significant for five of the eight aircraft types for estimating the number of aircraft. With regard to the estimation of hours, variables costs are not significant for four of the aircraft types.

Notwithstanding these apparent anomalies, the individual time-series regression equations were used to estimate the 1972 activity measures for comparison to observed values. The results of these calculations are given in Table 13. Comparing Tables 13 and 11, the individual time-series model appears to be generally superior to the pooled model in this particular case.

Pooled Turbine-Aircraft Model

Although the time-series model appears to give reasonable accuracy the smaller, less sophisticated aircraft (Types 1, 2, and 3) require additional consideration. The lack of significance of several of the coefficients in Table 12 suggests that the basic form of the regression equation is not correct, at least for predicting the number of aircraft in the fleet. It is possible that the less sophisticated aircraft are acquired for reasons not completely related to business utility or productivity. Conversely, it could be conjectured that the more sophisticated aircraft would more likely be purchased on measurable

TABLE 12. COEFFICIENTS OF TIME-SERIES REGRESSION EQUATIONS

Aircraft Type	Number of Aircraft						Hours Flown			
	a_o	a_1	a_2	a_3	a_4	$\overline{R}2$	b_o	b_1	b_2	$\overline{R}^2$
1	16.33 (3.28)	--	--	-1.96 (-1.76)	--	0.38	1.233 (0.49)	1.180 (1.69)	--	0.36
2	5.22 (2.93)	0.575 (2.57)	--	--	--	0.57	-4.084 (-1.91)	0.667 (4.35)	4.041 (4.10)	0.95
3	2.54 (1.67)	--	1.63 (4.33)	--	--	0.79	24.192 (2.62)	0.933 (3.81)	-5.587 (-2.06)	0.79
6	-10.61 (-3.17)	0.916 (22.14)	3.44 (3.72)	--	--	0.99	121.996 (2.70)	6.010 (6.03)	-32.532 (-2.97)	0.90
7	5.78 (11.10)	-0.075 (-0.73)	--	--	--	0.10	5.660 (3.96)	-0.165 (-0.41)	--	0.03
8	-0.0796 (-0.75)	0.874 (154.24)	-0.471 (-25.09)	0.683 (32.93)	--	0.99	-2.244 (-3.34)	2.062 (11.00)	--	0.96
9	-3.65 (-1.62)	--	--	1.207 (2.68)	0.730 (12.62)	0.98	-8.553 (-5.40)	3.694 (8.35)	--	0.93
11	2.189 (3.55)	0.590 (3.97)	--	--	0.0761 (2.08)	0.85	-66.816 (-4.86)	--	11.647 (5.16)	0.84

NOTE: Numbers in parentheses are t-statistic values.

TABLE 13. 1972 ESTIMATES FROM INDIVIDUAL TIME-SERIES MODELS

Aircraft Type	Fleet Size Actual	Fleet Size Estimated	Utilization Actual	Utilization Estimated
1	3,151	1,953	340,528	319,772
2	22,942	21,930	4,045,822	4,299,532
3	11,640	11,206	3,363,960	3,096,323
6	1,002	1,052	525,048	496,786
7	213	221	159,963	152,311
8	538	538	305,046	292,959
9	405	392	254,745	282,203
11	220	240	135,740	126,365

financial principles. For this reason, a third regression model was generated by pooling the data for turbine-powered aircraft.

The resulting relationships are:

Number of Aircraft

$$\ln N = \underset{(-1.94)}{-3.59} + \underset{(11.53)}{0.732} \ln H + \underset{(4.93)}{0.751} \ln \frac{PRD}{FC}$$

$$+ \underset{(2.93)}{1.20} \ln (N-1) + \underset{(1.48)}{0.551} \ln PRF$$

$$\bar{R}^2 = 0.92$$

Number of Hours

$$\ln H = \underset{(-0.63)}{-1.158} + \underset{(5.26)}{2.478} \ln ECH - \underset{(-3.68)}{0.535} \ln VC$$

$$\bar{R}^2 = 0.56$$

A comparision between estimated and actual 1972 data is presented in Table 14. The model appears to be better than the one obtained by pooling all aircraft types.

TABLE 14. 1972 ESTIMATES FOR POOLED TURBINE-AIRCRAFT MODEL

Aircraft Type	Fleet Size		Utilization	
	Actual	Estimated	Actual	Estimated
6	1,002	931	525,048	437,329
7	213	233	159,963	249,991
8	538	641	305,046	241,400
9	405	524	254,745	189,433
11	220	282	135,740	159,688

Comments on Regression Analysis

It does not appear possible to derive a single regression model that will adequately explain the behavioral activity peculiar to each aircraft type. Particularly with piston-powered aircraft, the activity measures seem to be mostly dependent upon qualitative factors. Only the regression relationships derived for turbine-powered aircraft can be applied to forecasting with confidence.

Business Aircraft Owner Characteristics

In an effort to provide greater insight into the nature of the business fleet, the business characteristics of the operators of approximately 3,350 corporate-owned aircraft were examined. Aviation Data Service, Inc. provided its annual analysis of the aircraft operators within the "Fortune 1000" industrial corporations for the year 1972. Furthermore, a sampling of 2,000 additional corporate owned aircraft was provided by ADS. The intent of the sampling plan was that the ratio of the number of aircraft within each type to the total number of aircraft in the sample would be equal to the ratio of the total number of aircraft within that type to the total corporate aircraft population.

Concerning the large industrial firms contained in the "Fortune 1000" group, Figure 1 illustrates the tendency for the percentage of companies owning aircraft to increase as the sales volume increases.

As might be expected, the distribution of aircraft, by type, for the "Fortune 1000" industrials is not similar to the distribution of the business fleet as a whole. These distributions are shown in Figure 2 and illustrate the heavy bias of the industrial giants toward the more sophisticated aircraft.

From the owner characteristics data provided by ADS, several significant financial ratios were constructed. These ratios were: Net Income/Net Worth, Sales/Net Worth, and Net Income/Sales. Since these ratios are generally meaningful only when making comparisons within the same industry, they were normalized with respect to the average value of each ratio within nine major Standard Industrial Code classifications. Histograms of the number of aircraft as a function of the normalized financial ratios were constructed for each major SIC classification and these are contained in Volume Ii, Chapter 3. A sample figure is included here, for the agriculture industry, as Figure 3.

CONCLUDING REMARKS

Cost Sensitivity

Nine user subcategories have been identified, within the general Business/Corporate user category, with differing yearly after-tax ownership costs for a given aircraft type. The differences are caused by the variation in the tax rates, crew costs, and financing or lease costs among the user subcategories.

The methodology of this study appears to offer a relatively comprehensive and rational means for estimating the cost sensitivity of business aviation as a whole, or of individual subsegments, to changes in the basic cost centers.

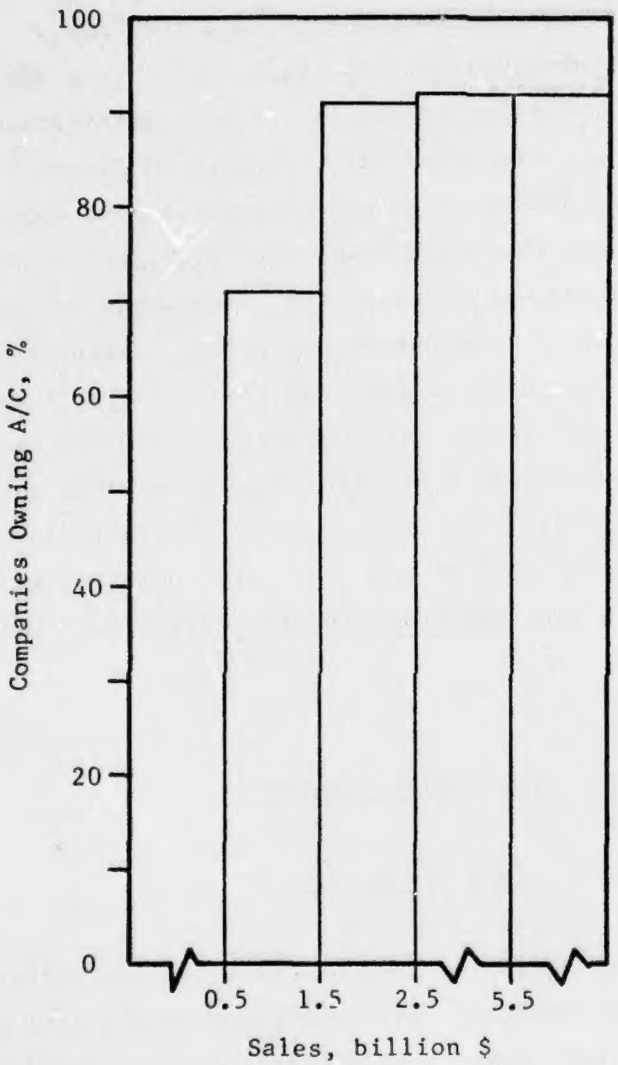

FIGURE 1. PERCENTAGE OF FORTUNE 1000 COMPANIES WHICH OPERATE BUSINESS AIRCRAFT

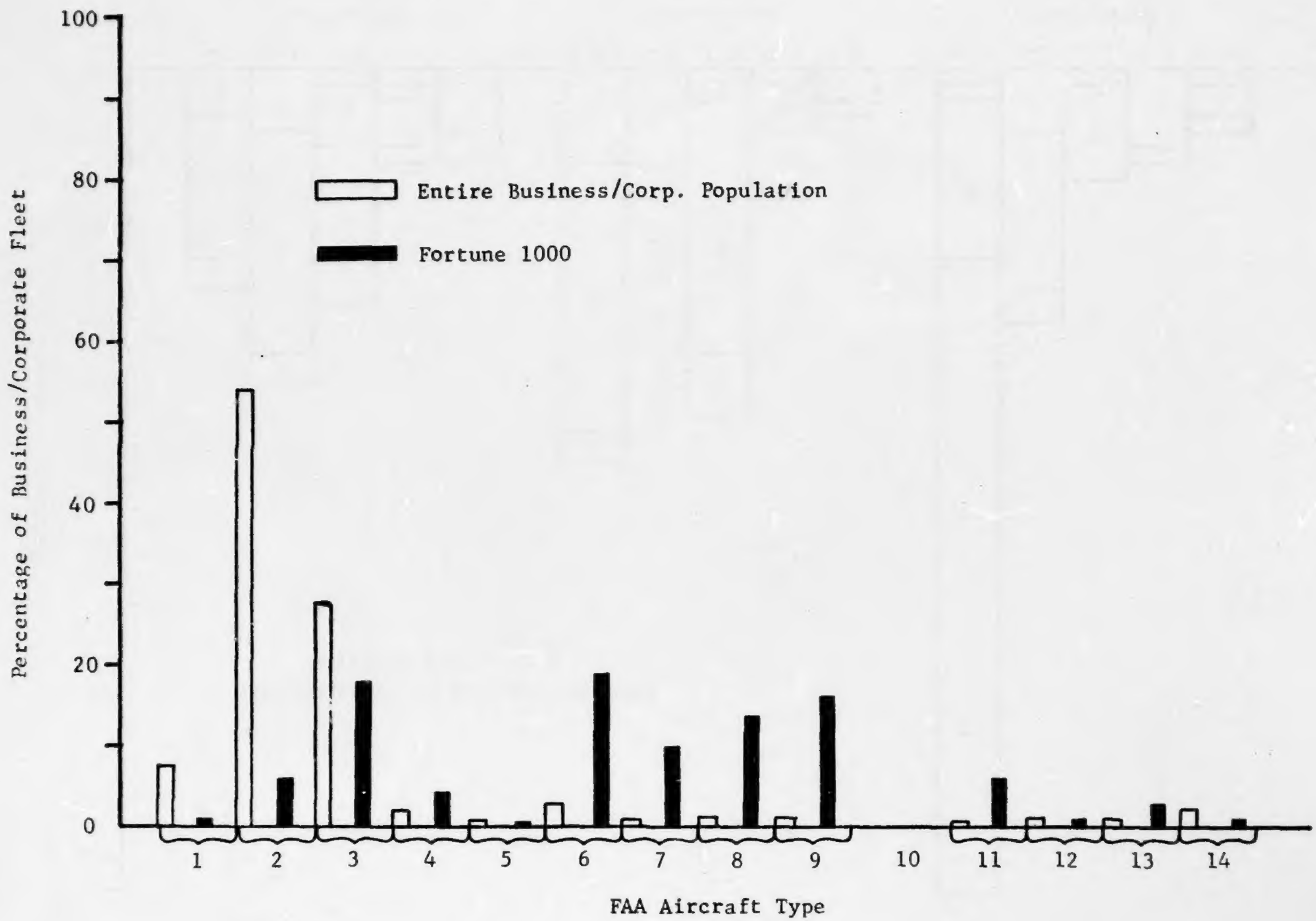

FIGURE 2. DISTRIBUTION BY AIRCRAFT TYPE

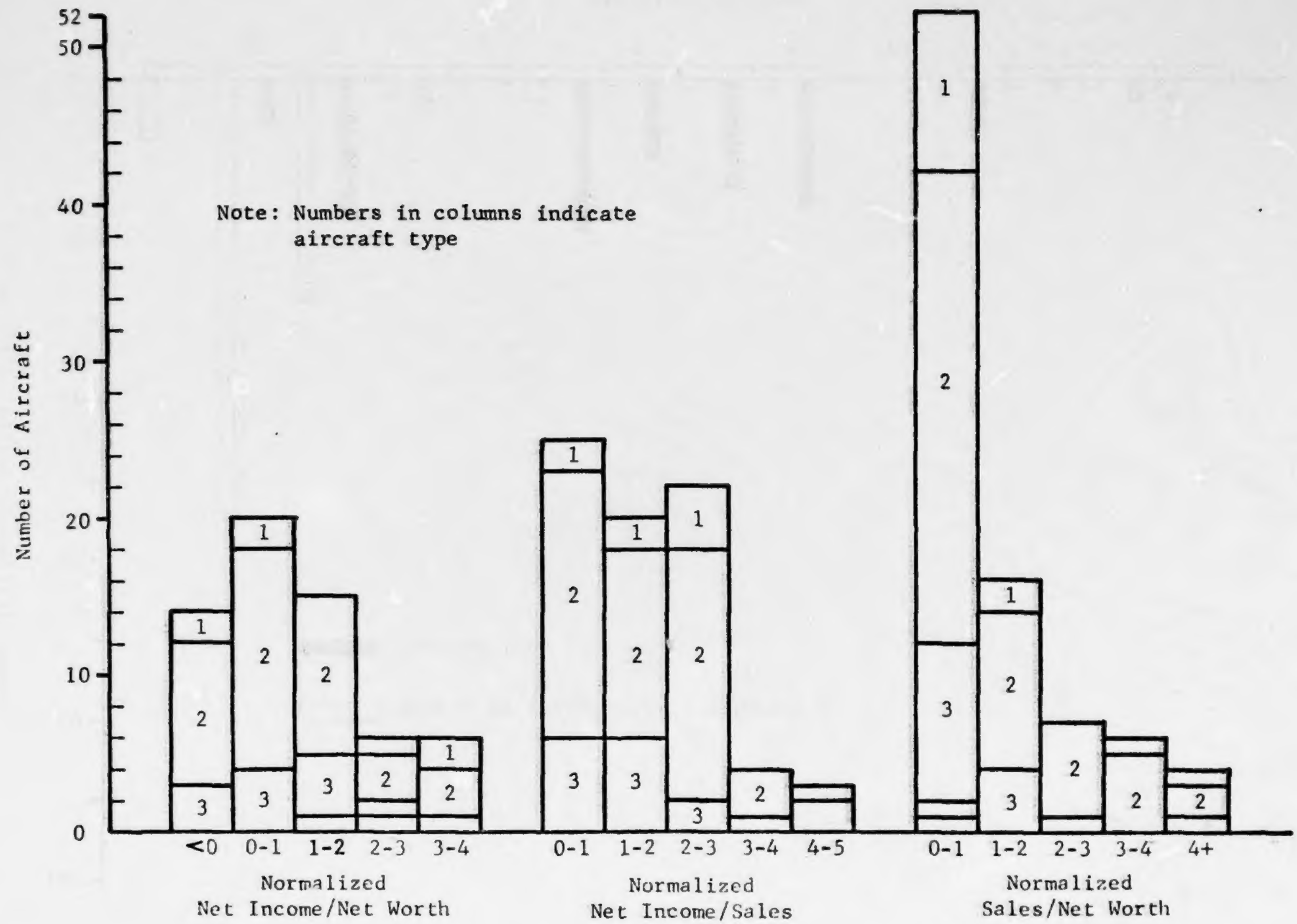

FIGURE 3. DISTRIBUTION OF AIRCRAFT - AGRICULTURE INDUSTRY

In comparison to the previous Cost Impact Study procedure, the inclusion of flight crew costs tends to offset the tax benefits in the computation of the Annualized Investment cost center. Since other cost centers are reduced by tax benefits to a greater degree, the relative contribution of the Annualized Investment to total costs is increased.

Cost Impact

It is not possible to develop cost-impact regression models for individual subcategories because of the lack of corresponding detail in the historical data base. Furthermore, it does not appear possible to derive a single regression model that will adequately explain the behavioral activity peculiar to each aircraft type. Particularly with piston-powered aircraft, the activity measures seem to be largely unexplained by the independent variables used in the analysis. Only the regression relationships derived for turbine-powered aircraft can be applied to forecasting with confidence.